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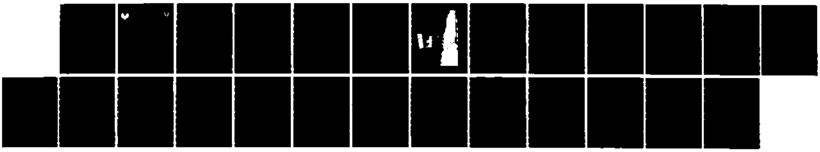

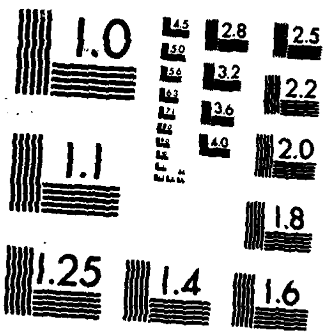

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REPORT NO. USACSTA-6412

US ARMY
MATERIEL COMMAND

AD-A173 030

RESEARCH REPORT

MEASUREMENTS OF 14-MEV NEUTRON PROPAGATION IN AN AIR-OVER-GROUND GEOMETRY

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DE L'ARMEMENT ARCUEIL, FRANCE

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Measurements have been made of the propagation of neutrons from a 14-MeV source into a free-field air-over-ground geometry. Neutron, gamma-ray, and total kerma have been measured at distances ranging from 100 to 800 meters from the source. Agreement with calculations is satisfactory.

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U.S. ARMY COMBAT SYSTEMS TEST ACTIVITY

MEASUREMENTS OF 14-MEV NEUTRON PROPAGATION IN AN AIR-OVER-GROUND GEOMETRY

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1. INTRODUCTION

The propagation of 14-MeV neutrons in an air-over-ground geometry is of military significance because of the potential use of fusion and "enhanced radiation" nuclear weapons on the battlefield. A major component of the output of these weapons is composed of 14-MeV neutrons, and the effective propagation of these neutrons to the target area is often the controlling factor in the survival or destruction of the target.

Because of this military significance, the U.S. Army, through the Army Pulse Radiation Facility (APRF) of the Nuclear Effects Directorate, U.S. Army Combat Systems Test Activity, at Aberdeen Proving Ground (APG), participated in a program conducted by the Etablissement Technique Central de L'Armement (ETCA) of the Government of France. In this program, a 14-MeV neutron generator was placed in a tower to be used as a source of neutrons for various experiments. This report concerns the propagation of 14-MeV neutrons through the air as a function of distance. These air-transmission measurements provide a check of transport calculation results and demonstrate the utility of the ETCA facility for making radiation-shielding measurements on armored vehicles.

Measurements similar to these have already been made using the APRF reactor as a source of fission neutrons (ref 1 to 5). Part of the purpose of the 14-MeV experiments was to form a basis for the comparison of the behavior of the two types of neutrons.

2. EXPERIMENTAL SETUP

Figure 1 shows the tower with the accelerator in place. The target of the accelerator was 14 meters above ground level, and oriented such that the deuteron beam was horizontal, pointed in the direction of the measurement locations. The measurement area was a rectangular grassy field, about 300 meters wide and 1.5 km long, with trees growing beyond these boundaries. The accelerator was located in the center of one of the narrow edges of this rectangle, and the measurement locations were in the middle of the field, out to 800 meters. Distances were measured from the point on the ground directly below the accelerator target. At the foot of the tower was a boron-lined

proportional counter which was used to monitor the source neutron flux during each measurement. The calibration constant used here was 1.971E+8 neutrons (4 PI) per count. The maximum source strength was about 5.0E+11 n/s, but this varied with the condition of the target.

Three types of detectors were used to make measurements: a tissue-equivalent ion chamber, a gamma-dose ion chamber, and a set of Bonner spheres. The detector height was approximately 2 meters above the ground for all measurements.

The tissue-equivalent ion chamber was used in two modes. In the first mode the current from a 16-liter volume ion chamber was measured and converted to dose-rate per unit time. The boron counter used as source monitor was then used to convert this to dose rate per source neutron. In the second mode, two 16-liter ion chambers were used in parallel and the currents summed to give the dose rate. This increased the sensitivity to kerma by about a factor of two. The ion chambers are made of tissue-equivalent plastic with a tissue-equivalent gas filling so that the response is proportional to total (neutron plus gamma) tissue kerma. The ion chambers are estimated to have a calibration uncertainty of 5%; drifting of the electronics, noise, and background subtraction add to the uncertainty. Quoted errors include all effects. Tissue-equivalent ion chamber data is recorded in Appendix A.

The gamma-ray ion chamber was a high-pressure (300 psi) stainless steel ion chamber with argon gas filling (Reuter-Stokes model RSS-111). The chamber was used while still in its steel protective case. The readout is directly in micro-Rad/hr and this number was converted to dose rate per source neutron with the use of the boron monitor. Corrections had to be made for neutron sensitivity and for sensitivity to variations in the gamma-ray spectrum (ref 6). These effects cause a minimum uncertainty of about 10%. As with the tissue-equivalent ion chamber, there is additional uncertainty due to noise and background subtraction. Gamma-ray ion chamber data is recorded in Appendix B.

The Bonner spheres consist of a 4x4 mm LiI(Eu) scintillator connected by a plexiglass light pipe to an RCA 6199 photomultiplier. All counts above a threshold level were counted. The threshold was fixed at 0.71 times the height of the thermal neutron peak. The neutron/gamma separation was excellent. The detector was used bare, with a cadmium cover of 1.0 mm, or with covering polyethylene spheres of 2, 3, 5, 8, 10, and 12 inches diameter. These count rates, using the boron monitor for source normalization, were used with the corresponding reponse functions to unfold neutron spectra. These spectra were then integrated to give kerma results. The Bonner spheres have very low resolution, so that the resultant spectra and kerma are quite sensitive to the source spectra used as inputs to the unfolding process. A variety of guess spectra were used for determining the kerma, and the estimated uncertainties of the neutron kerma reflect dependence on the guess spectra. Bonner sphere data are reported in Appendix C, and the response functions used are given in Appendix D. The unfolded spectra are listed in Appendix E.

Uncertainty in the source neutron flux is not included in the quoted uncertainties. This error is systematic, resulting in an overall normalization uncertainty, and is estimated to be about 10%.

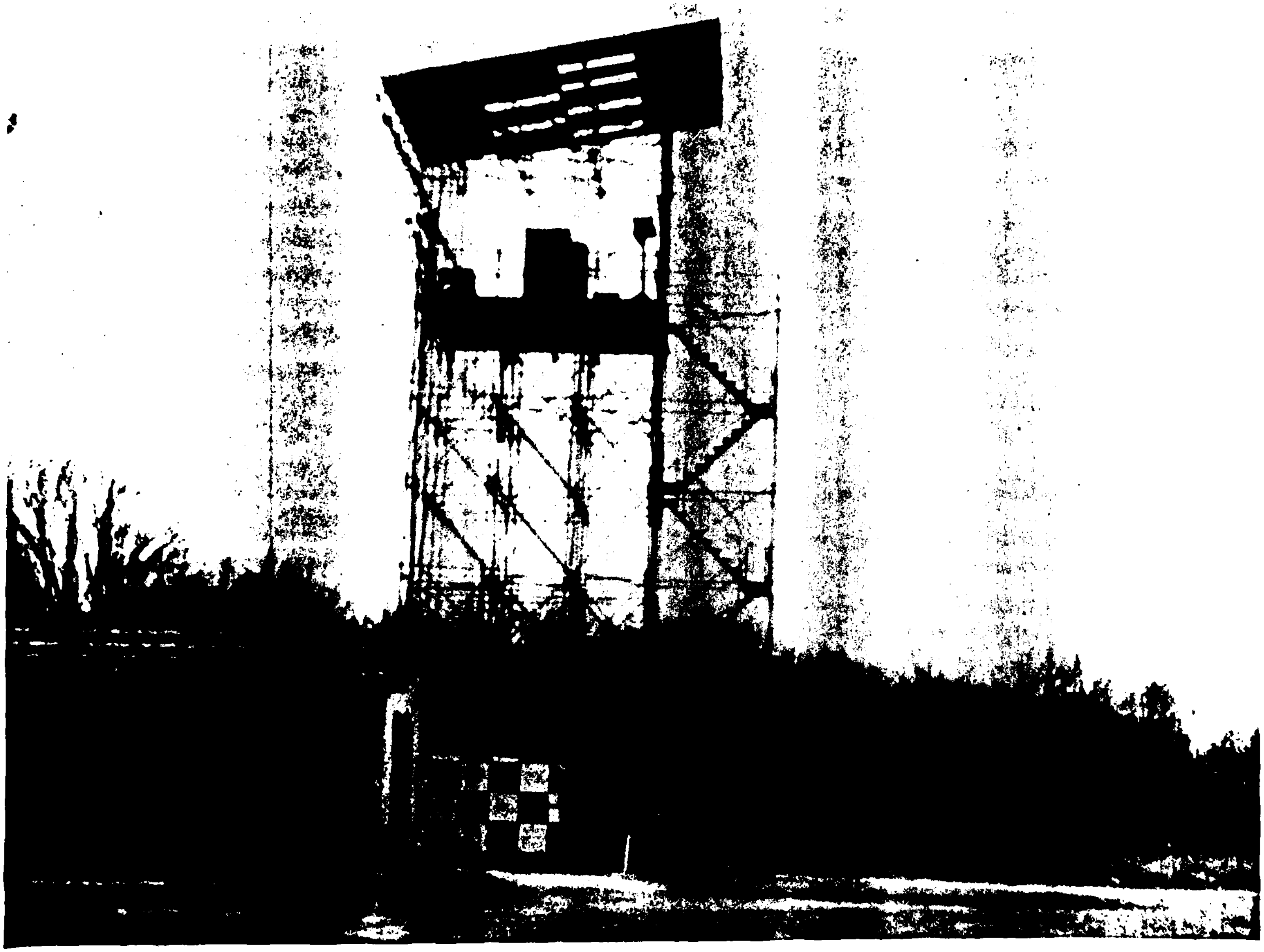

Figure 1. 14-MeV generator on 14-meter high tower at ETCA, France.

3. RESULTS

The measured free-field kerma are summarized in Table 1. These data are graphed in Figure 2. Both neutron and gamma kerma approach an EXP(-cx)/r**2 distribution with distance, with the relaxation constant 1/c being approximately 230 and 300 meters for neutron and gamma kerma, respectively. The data taken in the period 19 to 27 April are about 10% below the data taken in the period 28 to 31 May. Possible causes of this are variations in humidity, source monitor variations, or drift in the detectors. The data is sufficiently good, however, to form a tight constraint for any comparison with calculations.

Since neutron, gamma, and total kerma were measured independently, there is no constraint that measured neutron-plus-gamma equal the total kerma. Therefore, a test of the self-consistency of the data is to compare these two methods of finding the total kerma. This is accomplished in the last column of Table 1. The data is self-consistent within 10% at all ranges. This is not a tight constraint on the gamma kerma because it is such a small fraction of the total.

Figure 3 shows how the neutron spectrum changes with distance. The spectra shown in this figure were all obtained with the same guess spectrum, so that differences in spectra are due entirely to differences in the measured data. All the features in the 800 meter spectrum were already present at 100 meters. The major trend in these results is the declining importance of the 14-MeV peak relative to the total flux. This can be seen from the fact that the 14-MeV peaks drop faster with distance than the slower portion of the spectrum.

TABLE 1. MEASURED FREE-FIELD KERMA

DISTANCE (m)	NEUTRON KERMA (Rad/SN)	GAMMA KERMA (Rad/SN)	TOTAL KERMA (Rad/SN)	NEUTRON+GAMMA / TOTAL KERMA
101	0.52E-17(10%)	0.139E-17(15%)	7.00E-18(10%)(a)	0.94
200	0.97E-18(10%)	0.297E-18(15%)	1.29E-18(10%)	0.98
301	0.31E-18(12%)	0.107E-18(15%)	3.88E-19(10%)	1.07
402	1.12E-19(12%)	0.466E-19(15%)	1.43E-19(10%)	1.11
402	0.92E-19(12%)	0.471E-19(15%)	1.57E-19(10%)	0.88
523	0.41E-19(15%)	0.194E-19(15%)	---	
600	0.20E-19(15%)	0.111E-19(15%)	0.333E-19(15%)	0.93
600	---	0.126E-19(15%)	---	
700	---	0.642E-20(15%)	0.135E-19(15%)	
800	0.47E-20(25%)	0.274E-20(20%)	---	

(a) Estimated uncertainties given in parentheses.

3 (Cont'd)

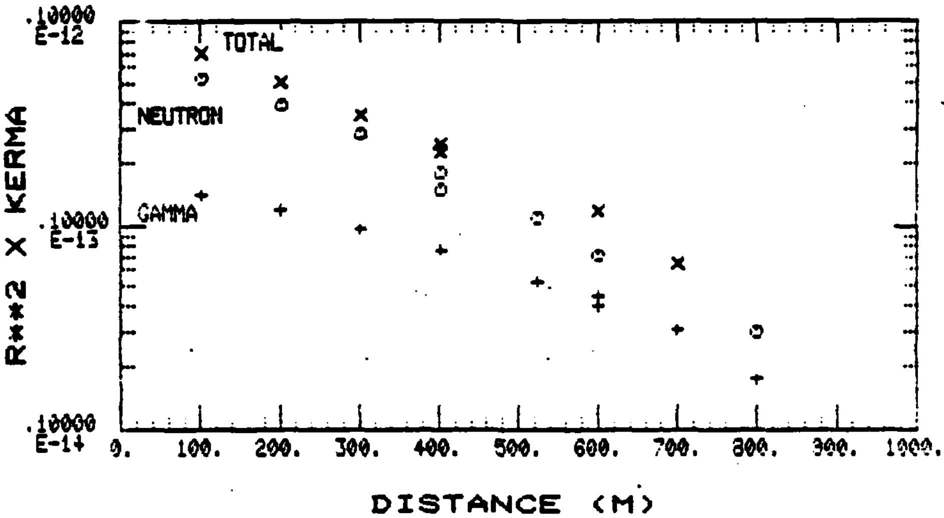

Figure 2. Kerma versus distance.

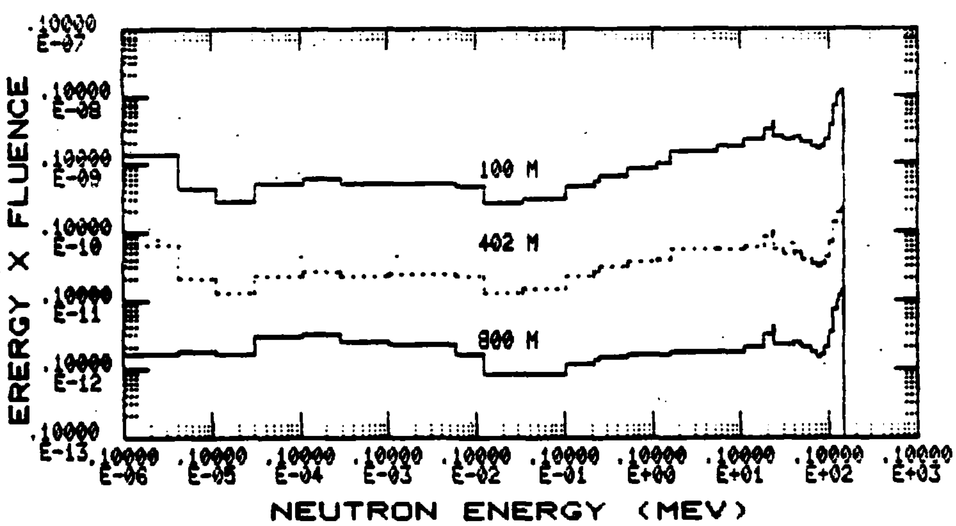

Figure 3. Typical 14-MeV spectra.

4. COMPARISON WITH CALCULATIONS

The experimental data can be compared with the calculational results given in Reference 7. Figures 4, 5, and 6 show the gamma-ray, neutron, and total-dose comparisons, respectively. The calculations refer to an isotropic source of neutrons 15.2 meters above an air-ground interface. The energy spectrum of the source is uniform over the 12.2- to 15-MeV energy range. The air composition used for the calculation contains no water vapor and has a density of 0.0011 g/cc. In the experiment, there was water vapor in the air, and the density averaged about 0.0012 g/cc. In the comparisons of Figures 4 to 6, the calculated results are corrected for air density. There is no simple technique to correct for the effects of water vapor in the air.

The comparison of measured and calculated neutron kerma shown in Figure 4 shows good agreement at all distances measured. The calculations are slightly below the measurements at distances closer than 500 meters and slightly above the measurements at longer distances, but agreement is within the uncertainties at all distances.

The comparison of the gamma-ray kerma in Figure 5 shows the calculated kerma below the measured kerma near the source. This is because the calculations did not include source gamma rays, but only gamma rays generated by neutrons in the environment. At longer distances from the source, these secondary gamma-rays become more dominant, and agreement becomes better beyond 600 meters.

The comparison of total kerma shown in Figure 6 reflects the neutron and gamma-ray results. The calculations are below the measurements at short distances, reflecting the lack of source gamma-rays in the calculations. Beyond 400 meters, agreement is good.

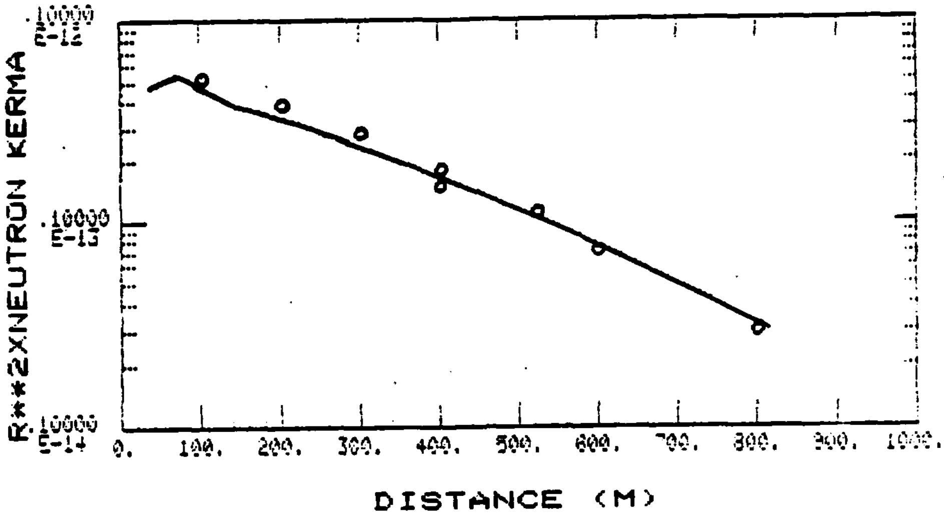

Figure 4. Comparison of calculated (line) and measured (circles) neutron kerma at distances of 100 to 800 meters.

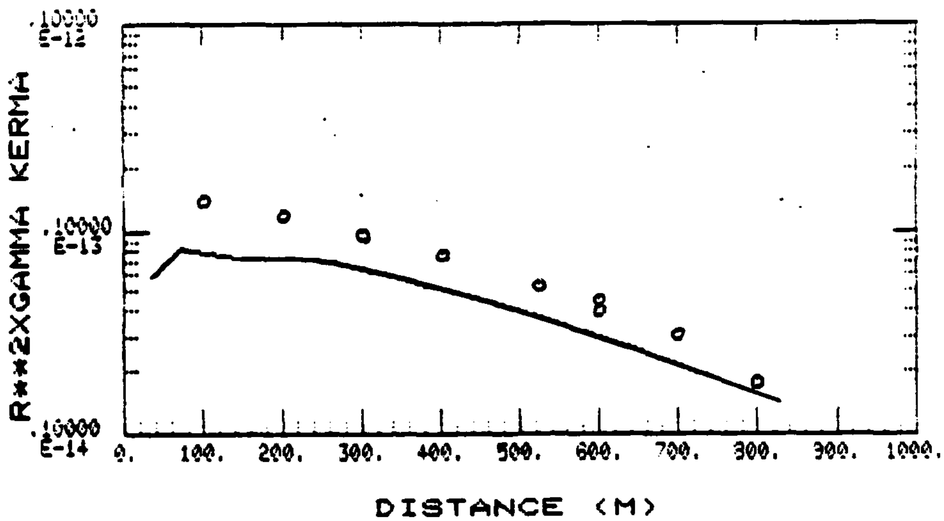

Figure 5. Comparison of calculated (line) and measured (circles) gamma-ray kerma at distances of 100 to 800 meters.

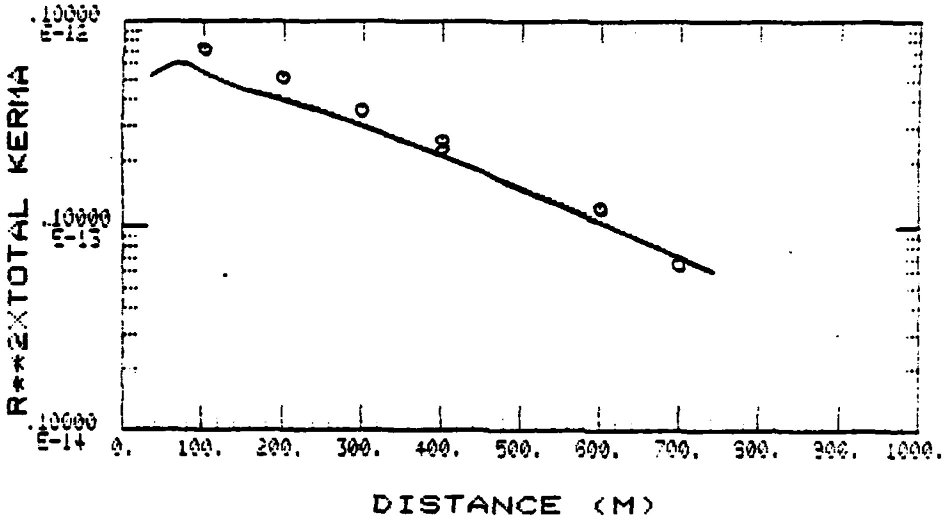

Figure 6. Comparision of calculated (line) and measured (circles) total kerma at distances of 100 to 700 meters.

5. CONCLUSIONS

Measurements have been made of the transmission of 14-MeV neutron and associated gamma-ray radiation out to 800 meters from the source in an air-over-ground geometry. The measurements tend to validate a set of transport calculations made by Straker (ref 7).

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7. Time-Dependent Neutron and Secondary Gamma-Ray Transport in an Air-Over-Ground Geometry, Volume II. Tabulated Data, E. A. Straker, *ORNL-4289 (Vol II)* (1968).

APPENDIX A - FREE-FIELD TISSUE-EQUIVALENT ION CHAMBER DATA

DATE (a)	TIME	DIST (m)	TEMP ('C)	PRESS (mbar)	REL HUM (%)	DOSE (Rad/Source Neut)
19 APR 84	17:00	402	20	1006	26	1.46E-19
20 APR 84	9:30	402	14	1008	60	1.40E-19
20 APR 84	10:30	301	15	1008	55	3.88E-19
20 APR 84	11:00	200	16	1008	40	1.29E-18
20 APR 84	11:30	101	16	1008	35	7.00E-18
25 APR 84	15:30	402	21	1006	18	1.45E-19
26 APR 84	9:47	402	12	1007	75	1.62E-19
26 APR 84	19:15	200	18	1004	30	1.14E-18
28 MAY 84(b)	17:54	402	13	991	70	1.57E-19
28 MAY 84(b)	18:27	402	13	991	70	1.58E-19
28 MAY 84(b)	21:02	600	13	991	72	3.33E-20
28 MAY 84(b)	21:38	700	13	991	72	1.35E-20

(a) Unless otherwise marked, data was taken with single 16 liter ion chamber, calibrated at 6.73E+8 R/amp-hr.
(b) Data taken with two 16 liter ion chambers operated in parallel, calibrated at 3.33E+8 R/amp-hr.

APPENDIX B - GAMMA-RAY ION CHAMBER MEASUREMENTS

DATE	TIME	DIST (m)	TEMP ('C)	PRESS (mbar)	REL HUM (%)	UNCORR. DOSE (Rad/SN)	CORRECTED DOSE (Rad/SN)
19 APR 84	17:00	402	20	1006	26	4.95E-20	3.48E-20
20 APR 84	9:30	402	14	1008	60	4.66E-20	3.25E-20
20 APR 84	10:30	301	15	1008	55	1.07E-19	7.22E-20
20 APR 84	11:00	200	16	1008	40	2.97E-19	1.98E-19
20 APR 84	11:30	101	16	1008	35	1.39E-18	9.35E-19
24 APR 84	19:45	523	20	1006	35	1.94E-20	1.35E-20
25 APR 84	10:35	523	15	1008	55	1.88E-20	1.31E-20
25 APR 84	11:30	600	16	1008	35	1.11E-20	7.90E-21
26 APR 84	9:47	402	12	1007	75	4.43E-20	3.06E-20
27 APR 84	9:30	800	12	1007	65	2.74E-21	2.02E-21
28 MAY 84	18:12	402	13	991	70	4.71E-20	3.29E-20
28 MAY 84	21:00	600	13	991	72	1.26E-20	9.14E-21
28 MAY 84	21:33	700	13	991	72	6.42E-21	4.71E-21

APPENDIX C - BONNER SPHERE DATA

DATE	24APR	24APR	24APR	24APR	24APR
TIME	15:00	16:30	17:30	18:30	20:30
DIST(m)	402	100	200	300	523
TEMP('C)	22	23	24	23	18
PRESS(mbar)	1008	1006	1006	1006	1006
REL HUM(%)	31	27	25	25	40
Counts/SN					
Bare	2.12E-12	4.58E-11	1.25E-11	4.58E-12	8.49E-13
CD	4.75E-13	1.08E-11	2.60E-12	1.02E-12	2.70E-13
2in	4.32E-12	9.38E-11	2.35E-11	9.07E-12	1.55E-12
3in	6.69E-12	1.62E-10	4.00E-11	1.40E-11	2.74E-12
5in	8.65E-12	2.37E-10	5.63E-11	2.12E-11	3.45E-12
8in	7.17E-12	2.44E-10	5.20E-11	1.85E-11	2.84E-12
10in	5.44E-12	2.05E-10	3.98E-11	1.50E-11	2.04E-12
12in	4.06E-12	1.72E-10	3.31E-11	1.12E-11	1.55E-12

DATE	25APR	27APR	28MAY
TIME	11:30	21:30	18:00
DIST(m)	600	800	402
TEMP('C)	15	17	13
PRESS(mbar)	1008	1004	991
REL HUM(%)	39	35	70
Counts/SN			
Bare	5.51E-13	1.04E-13	2.14E-12
CD	8.56E-14	4.46E-14	4.21E-13
2in	9.97E-13	3.36E-13	3.90E-12
3in	1.61E-12	4.09E-13	6.48E-12
5in	1.99E-12	5.00E-13	8.41E-12
8in	1.54E-12	2.65E-13a	6.72E-12
10in	1.19E-12	2.74E-13	4.84E-12
12in	8.02E-13	1.89E-13	3.80E-12

(a) Data suspect.

APPENDIX D - BONNER SPHERE RESPONSE FUNCTIONS

Energy group structure (Bin edges in MeV)

0.1000E-08	0.4140E-06	0.1130E-05	0.3060E-05
0.1070E-04	0.2900E-04	0.1010E-03	0.5800E-03
0.1230E-02	0.3350E-02	0.1030E-01	0.2190E-01
0.2480E-01	0.5250E-01	0.1110E+00	0.1579E+00
0.5500E+00	0.1110E+01	0.1830E+01	0.2310E+01
0.2390E+01	0.3010E+01	0.4070E+01	0.4720E+01
0.4970E+01	0.6380E+01	0.7410E+01	0.8190E+01
0.9050E+01	0.1000E+02	0.1110E+02	0.1220E+02
0.1280E+02	0.1380E+02	0.1420E+02	0.1490E+02
0.1690E+02	0.1960E+02		

Bonner sphere group responses (counts/n/cm**2)

BARE

0.11457E+00	0.10651E+00	0.86290E-01	0.63456E-01
0.45158E-01	0.27424E-01	0.13164E-01	0.69213E-02
0.47990E-02	0.31522E-02	0.17326E-02	0.10666E-02
0.78090E-03	0.47452E-03	0.34463E-03	0.23324E-03
0.12581E-03	0.86969E-04	0.74801E-04	0.70316E-04
0.65568E-04	0.56210E-04	0.48595E-04	0.45180E-04
0.39773E-04	0.32950E-04	0.28647E-04	0.25174E-04
0.21705E-04	0.19562E-04	0.18743E-04	0.18160E-04
0.17649E-04	0.17224E-04	0.16906E-04	0.16179E-04
0.15044E-04			

CD

0.51253E-02	0.36530E-01	0.46953E-01	0.41849E-01
0.34376E-01	0.24240E-01	0.13164E-01	0.69213E-02
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0.15044E-04			

2IN

0.10300E+00	0.18000E+00	0.18000E+00	0.16000E+00
0.14000E+00	0.11000E+00	0.89000E-01	0.71000E-01
0.59881E-01	0.48785E-01	0.40049E-01	0.35752E-01
0.32021E-01	0.26620E-01	0.23111E-01	0.17228E-01
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0.26671E-03			

3IN

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0.16814E+00	0.15874E+00	0.15252E+00	0.15038E+00
0.14254E+00	0.12896E+00	0.11759E+00	0.94188E-01
0.67162E-01	0.48095E-01	0.36964E-01	0.32831E-01
0.28450E-01	0.20511E-01	0.15850E-01	0.14638E-01
0.12740E-01	0.10648E-01	0.94360E-02	0.84576E-02
0.74804E-02	0.67702E-02	0.63406E-02	0.60346E-02
0.57667E-02	0.55439E-02	0.53774E-02	0.49958E-02
0.44003E-02			

5IN

0.45232E-01	0.75000E-01	0.85000E-01	0.10000E+00
0.12559E+00	0.13928E+00	0.15965E+00	0.17349E+00
0.18701E+00	0.20348E+00	0.21743E+00	0.22387E+00
0.23096E+00	0.24170E+00	0.24710E+00	0.25277E+00
0.23821E+00	0.19483E+00	0.16234E+00	0.15108E+00
0.13929E+00	0.11707E+00	0.99895E-01	0.92408E-01
0.83022E-01	0.71971E-01	0.65003E-01	0.59379E-01
0.53761E-01	0.49162E-01	0.45725E-01	0.43277E-01
0.41134E-01	0.39351E-01	0.38019E-01	0.34966E-01
0.30202E-01			

8IN

0.13400E-01	0.25000E-01	0.30000E-01	0.40000E-01
0.69153E-01	0.70592E-01	0.72579E-01	0.73881E-01
0.75006E-01	0.76341E-01	0.77430E-01	0.77915E-01
0.89049E-01	0.10930E+00	0.13053E+00	0.18278E+00
0.25532E+00	0.26996E+00	0.26185E+00	0.25722E+00
0.24794E+00	0.22352E+00	0.20315E+00	0.19381E+00
0.17903E+00	0.16039E+00	0.14863E+00	0.13914E+00
0.12966E+00	0.11872E+00	0.10696E+00	0.98595E-01
0.91268E-01	0.85172E-01	0.80617E-01	0.72602E-01
0.62072E-01			

10IN

0.05540E-01	0.10000E-01	0.15000E-01	0.21682E-01
0.24241E-01	0.26479E-01	0.29570E-01	0.31595E-01
0.33344E-01	0.35420E-01	0.37113E-01	0.37868E-01
0.42199E-01	0.55409E-01	0.73556E-01	0.11652E+00
0.17772E+00	0.22360E+00	0.24714E+00	0.25133E+00
0.25139E+00	0.24637E+00	0.23572E+00	0.22699E+00
0.21277E+00	0.18907E+00	0.17210E+00	0.15841E+00
0.14473E+00	0.13463E+00	0.12833E+00	0.12384E+00
0.11991E+00	0.11664E+00	0.11420E+00	0.10860E+00
0.99871E-01			

12IN

0.23491E-02	0.29387E-02	0.45233E-02	0.70558E-02
0.85624E-02	0.95755E-02	0.10000E-01	0.10034E-01
0.10686E-01	0.11633E-01	0.13485E-01	0.14774E-01
0.17088E-01	0.20987E-01	0.27036E-01	0.47408E-01
0.10276E+00	0.14639E+00	0.17488E+00	0.18374E+00
0.19284E+00	0.20841E+00	0.21584E+00	0.21672E+00
0.21760E+00	0.19840E+00	0.17918E+00	0.16735E+00
0.15706E+00	0.14901E+00	0.14343E+00	0.13945E+00
0.13597E+00	0.13307E+00	0.13091E+00	0.12595E+00
0.11820E+00			

APPENDIX E - BONNER SPHERE UNFOLDED RESULTS

Energy group structure (Bin edges in MeV)

0.1000E-08	0.4140E-06	0.1130E-05	0.3060E-05
0.1070E-04	0.2900E-04	0.1010E-03	0.5800E-03
0.1230E-02	0.3350E-02	0.1030E-01	0.2190E-01
0.2480E-01	0.5250E-01	0.1110E+00	0.1579E+00
0.5500E+00	0.1110E+01	0.1830E+01	0.2310E+01
0.2390E+01	0.3010E+01	0.4070E+01	0.4720E+01
0.4970E+01	0.6380E+01	0.7410E+01	0.8190E+01
0.9050E+01	0.1000E+02	0.1110E+02	0.1220E+02
0.1280E+02	0.1380E+02	0.1420E+02	0.1490E+02
0.1690E+02	0.1960E+02		

Unfolded Bonner-sphere spectra (n/cm**2-MeV-SN)

402M FF

0.31571E-04	0.25527E-05	0.60250E-06	0.32785E-06
0.13379E-06	0.34196E-07	0.72035E-08	0.23884E-08
0.55176E-09	0.20844E-09	0.13294E-09	0.10801E-09
0.77545E-10	0.45341E-10	0.30649E-10	0.15192E-10
0.66923E-11	0.40836E-11	0.38543E-11	0.41588E-11
0.20305E-11	0.13664E-11	0.11248E-11	0.94231E-12
0.69438E-12	0.48265E-12	0.39060E-12	0.39075E-12
0.45613E-12	0.66094E-12	0.11429E-11	0.14760E-11
0.14795E-11	0.14826E-11	0.14851E-11	0.35115E-35
0.35223E-35			

100M FF

0.65569E-03	0.58104E-04	0.14183E-04	0.76068E-05
0.30331E-05	0.75252E-06	0.15191E-06	0.49861E-07
0.11570E-07	0.44035E-08	0.28398E-08	0.23267E-08
0.17073E-08	0.10425E-08	0.74207E-09	0.41201E-09
0.21639E-09	0.15163E-09	0.15654E-09	0.17402E-09
0.87701E-10	0.62859E-10	0.54213E-10	0.46232E-10
0.34951E-10	0.24558E-10	0.19849E-10	0.19939E-10
0.23443E-10	0.34285E-10	0.59927E-10	0.78050E-10
0.78872E-10	0.79614E-10	0.80210E-10	0.19238E-33
0.19672E-33			

200M FF

0.19147E-03	0.13768E-04	0.31937E-05	0.17097E-05
0.69263E-06	0.17609E-06	0.36997E-07	0.12616E-07
0.29963E-08	0.11701E-08	0.77244E-09	0.64035E-09
0.47055E-09	0.28402E-09	0.19663E-09	0.10221E-09
0.48639E-10	0.31069E-10	0.30222E-10	0.33002E-10
0.16354E-10	0.11353E-10	0.95851E-11	0.81242E-11
0.60986E-11	0.42736E-11	0.34557E-11	0.34723E-11
0.40838E-11	0.59517E-11	0.10326E-10	0.13370E-10
0.13436E-10	0.13495E-10	0.13541E-10	0.32275E-34
0.32629E-34			

300M FF

0.67487E-04	0.56552E-05	0.13512E-05	0.70929E-06
0.28107E-06	0.68329E-07	0.13601E-07	0.43958E-08
0.10283E-08	0.39931E-09	0.26082E-09	0.21430E-09
0.15930E-09	0.99454E-10	0.71179E-10	0.38910E-10
0.18422E-10	0.11638E-10	0.11175E-10	0.12121E-10
0.59427E-11	0.40275E-11	0.33200E-11	0.27741E-11
0.20362E-11	0.14138E-11	0.11452E-11	0.11444E-11
0.13330E-11	0.19301E-11	0.33404E-11	0.43169E-11
0.43301E-11	0.43418E-11	0.43512E-11	0.10325E-34
0.10352E-34			

523M FF

0.89114E-05	0.13451E-05	0.39934E-06	0.21424E-06
0.81366E-07	0.18593E-07	0.29221E-08	0.80203E-09
0.17919E-09	0.67380E-10	0.42385E-10	0.34261E-10
0.25275E-10	0.15471E-10	0.10811E-10	0.56799E-11
0.25891E-11	0.15711E-11	0.14715E-11	0.15860E-11
0.77376E-12	0.51995E-12	0.42742E-12	0.35780E-12
0.26356E-12	0.18344E-12	0.14871E-12	0.14906E-12
0.17445E-12	0.25256E-12	0.43471E-12	0.55935E-12
0.55874E-12	0.55818E-12	0.55774E-12	0.12460E-35
0.12465E-35			

600M FF

0.99002E-05	0.41093E-06	0.82156E-07	0.45504E-07
0.19598E-07	0.55583E-08	0.14410E-08	0.57139E-09
0.14123E-09	0.56282E-10	0.37837E-10	0.31577E-10
0.22416E-10	0.12784E-10	0.83752E-11	0.38379E-11
0.15030E-11	0.86208E-12	0.78396E-12	0.83379E-12
0.39996E-12	0.25971E-12	0.20791E-12	0.17199E-12
0.12419E-12	0.85561E-13	0.69309E-13	0.69003E-13
0.79899E-13	0.11508E-12	0.19839E-12	0.25557E-12
0.25558E-12	0.25559E-12	0.25559E-12	0.60091E-36
0.59815E-36			

800M FF

0.76771E-06	0.22361E-06	0.74132E-07	0.42807E-07
0.15376E-07	0.36370E-08	0.64676E-09	0.17346E-09
0.36188E-10	0.12469E-10	0.73105E-11	0.56817E-11
0.36863E-11	0.18857E-11	0.11696E-11	0.50240E-12
0.20559E-12	0.13841E-12	0.14575E-12	0.16234E-12
0.82675E-13	0.61340E-13	0.53814E-13	0.45949E-13
0.35005E-13	0.24276E-13	0.19222E-13	0.18981E-13
0.21904E-13	0.32413E-13	0.59268E-13	0.79957E-13
0.83536E-13	0.86861E-13	0.89588E-13	0.21758E-36
0.23162E-36			

402M FF

0.33748E-04	0.21723E-05	0.49021E-06	0.26653E-06
0.11026E-06	0.29005E-07	0.63606E-08	0.22247E-08
0.53253E-09	0.20904E-09	0.13838E-09	0.11477E-09
0.82826E-10	0.48036E-10	0.31724E-10	0.14963E-10
0.62964E-11	0.36933E-11	0.34169E-11	0.36718E-11
0.17909E-11	0.12066E-11	0.99746E-12	0.83927E-12
0.62381E-12	0.43497E-12	0.35155E-12	0.35253E-12
0.41334E-12	0.60033E-12	0.10379E-11	0.13400E-11
0.13430E-11	0.13456E-11	0.13476E-11	0.31750E-35
0.31856E-35			

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